History of Electrical Engineering

Andre Marie Ampere
(1775–1836)

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Written By Bern Dibner

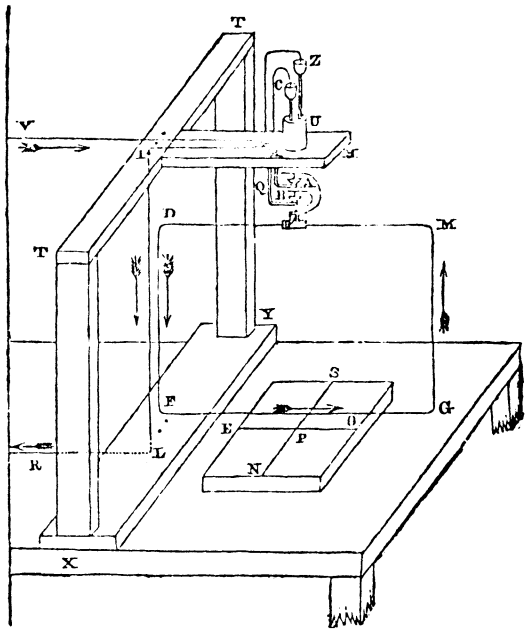
The invention of the voltaic cell in 1800 gave electrical experimenters a source of a constant flow of current. Seven years later the Danish experimenter, H. C. Oersted, announced that he would attempt to establish a relationship between an electric flow of current and a magnetic needle. Yet it required thirteen years more for this brilliant discovery to be made and announced by him in 1820.

The news of Oersted's experiment reached Paris through Arago who repeated the experiment at a meeting in Paris on September 11, 1820. In the audience was Ampere, then professor of mathematics of the Ecole Polytechnique. So deeply was Ampere impressed by the Oersted experiment that within a week he himself had repeated the experiment and elaborated it into a number of other basic relationships demonstrating the behavior of electric current flowing in straight and in formed conductors. On September 18th, Ampere presented before the Academy his observations establishing the science he designated as "electrodynamics." In a paper entitled "Experiments on the New Electrodynamical Phenomena," published in 1822, Ampere stated, "I have determined to use the word *electrodynamic* in order to unite under a common name all these phenomena, and particularly to designate those which I have observed between two voltaic conductors." He then distinguished electromotive action as being of two kinds, which he designated as those of *electric tension* and those of *electric current.* The former exists, he said, when two bodies are separated from each other by a nonconductor, such as the tension between the poles of a voltaic cell before they are connected by a conductor. In the case of flowing current the second exists where elements form part of a circuit of conducting bodies. Thus, pointed out Ampere, two bodies similarly charged electrostatically repel each other, whereas two conductors carrying currents in the same direction attract one another. Ampere was convinced that magnetism was an electrical phenomenon and that the direction of motion of a magnetic pole, when adjacent to a current-carrying wire, was neither towards nor away from the wire "but in a line at right angles to a plane passing through the pole and the conductor." The force of this attraction or repulsion, he proved, was directly proportional to the strength of the currents, and inversely proportional to the square of the distance between them, a relationship which prompted Clerk Maxwell to write that these achievements had "leaped full grown and fully armed from the brain of the Newton of Electricity."

The relationships between parallel wires were then expanded to include conductors bent into the forms of coils and helixes, some fixed and some free to move on pivots, and to show that such a spiral coil (solenoid) when carrying a current behaved exactly like a magnet. Such a coil, if delicately balanced and free to swing, should swing and adjust

itself to the earth's magnetic field; this he arranged and demonstrated, thereby causing a current-carrying wire to behave like a magnetic compass needle. He could then explain the earth's magnetism by terrestrial electric currents that circulated in the earth from east to west. Such currents, he speculated, might be caused by chemical action between the heterogeneous materials in contact within the globe, as Volta had demonstrated with different metals in contact.

Ampere formulated these observations into some general rules: (1) Two electric currents attract when they flow parallel to one another in the same direction and repel when they flow parallel to one another in the opposite direction. (2) It follows that when metallic conductors along which currents flow cannot turn into the parallel plane, each conductor tends to move the other conductor into a position parallel to it and in the same direction. (3) The attractions and repulsions are absolutely different from ordinary (electrostatic) electricity. (4) All the phenomena disclosed by Oersted regarding the relationship of the flow of an electric current and a magnet are covered by the law of attraction for two electric currents. This law follows from the deduction that a magnet is a product of electric currents produced by the action of the particles of iron on one another, similar to those of a voltaic pile.



From Ampère, "Exposé des Nouvelles Decouvertes sur L'Electricité", 1822.

Ampere recommended two experimental approaches to determining the mutual action of currents. The first consisted in actually measuring the forces at varying distances; the second consisted in balancing the effects produced by the two currents acting on a third body in keeping it in equilibrium. This second method (called the null method) is experimentally the more accurate. To apply the second method and determine if the forces were in true balance, Ampere arranged two coils on his apparatus and mounted them so that they were equally and oppositely affected by the earth's magnetism, forming, thereby, an *astatic* pair of coils. With this and similarly original equipment he arrived at the following four observations:

(1) The effect of a current is reversed when the direction of the current is reversed. (2) The effect of a current flowing in a circuit twisted into small turns is the same as if the circuit were expanded. (3) The force exerted by a flowing current on an element of another circuit is at right angles to the line uniting them. (4) The force between two elements of circuits is unaffected when all linear dimensions are increased proportionately, the current-strength remaining unaltered.

As one who had mastered the mathematics of his day at age 12, at 18 had read the main works of Lagrange, and later was a teacher of mathematics at Lyons and at Paris, Ampere had acquired habits of clear, exact thought which resolved ideas into quantitative elements. His electrical investigations were therefore developed into an hypothesis that magnetism was essentially a phenomenon of electrified particles of matter. It must be borne in mind that when Ampere was formulating his theories, there was still no conception of the idea of a difference of potential or that of electromotive force, and that Ohm's guiding law had yet to be determined, given to the world, and tested. Nor could Ampere show the difference between an electric current and the electromotive force that caused it to flow. He did state that a new instrument was available for detecting current flow and that from the nature of the new current to be measured this instrument should be called a *galvanometer.* Just as an electrometer measured "ordinary" electricity, so the new galvanometer would measure the flow of electricity. Ampere intended his instruments to operate along the lines of Oersted's pivoted needle but, a few months later, J. S. Schweigger of Halle brought out the first true galvanometer consisting of a coil of many turns of wire and a magnet hung on a silk thread in the center of the coil. Ampere suggested a method of signaling at a distance by placing a galvanometer in a circuit of great length.

The ideas propounded by Ampere found slow acceptance because his explanations of electric behavior showed the forces to act at right angles to the directions of flow of these forces and were therefore counter to Newton's ideas of forces acting in straight lines. However, later Ampere's explanations were endorsed by such recognized authorities as Fourier and Laplace and thereafter received ever-widening acceptance.

To Ampere the world of science owes a debt for his part in formulating the then little-understood electrical phenomena into a measurable and corroborative body of experiments and theory. His personal life was a disciplined and joyless one. His father was a victim of the excesses of the French Revolution, a tragedy that almost destroyed Ampere. His scientific interests were broad, and his published works included studies in mathematics, physics, chemistry, psychology and natural history in addition to those in electricity. In his advanced years he developed a new classification of all the sciences and, by a process of subdivision, reached a total of 128 sciences and subsciences including one he called "cybernetics," another "technesthetics." His work and his name have become perpetuated by action of the International Congress of Electricians who designated the practical unit of electric current as the *ampere.*